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ABSTRACT

The Cupertino-Fremont Model Technology Schools (MTS) Project was designed to provide teachers with working knowledge and access to technology while achieving an ultimate goal of integrating technology into instruction to develop students' higher order thinking. By the end of the project's third year, 15 months of research had been completed to determine if the MTS model was appropriate for the other sites and to know what to expect in developing other site implementations. Section 1 attributes differences in the three school's implementation processes to different grade spans (K-6, 7-8, and 9-12), faculty characteristics, administrative leadership, and evolution of project staff roles. Demographic facts for each school are provided. Acquisition, use, leveraging, and pooling of resources as well as project staff roles and professional development activities are discussed in section 2. Section 3 reports findings from questionnaires answered by 105 of the participating teachers to find out how frequently they used technology, which types they used, and how teaching and student attitudes were changed. Three tables illustrate survey results. Section 4 describes student, teacher, and school role changes and changes in district organization. Five sidebars supply additional project insights. (EJS)

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TEACHER-CENTERED MODEL OF TECHNOLOGY INTEGRATION: END OF YEAR 3

Cupertino–Fremont Model Technology Schools Project Research Findings

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PREFACE

The Cupertino–Fremont Model Technology Schools (MTS) project is based in three schools: Garden Gate Elementary School, Kennedy Junior High School, and Monta Vista High School, into which the former two feed. It was designed to provide teachers with access to technologies and the knowledge and skills needed to use them—with the ultimate goal of enhancing students' higher-order thinking. This Teacher-Centered Model of integrating technology into curriculum and instruction at all grade levels is one of six MTS demonstration projects throughout the state.

Access to technology, professional training, and individual support were arranged for or provided by project staff. They planned and worked in concert with the school site administrators, each of whom tailored the project activities to the individual school's context, progress, and objectives.

The three schools phased into the project. In the first year, project activities focused on the entire Garden Gate faculty. A cadre of six teachers from Kennedy and six from Monta Vista also began acquiring technology and developing the capability to use it. During the second year, project staff maintained activities in support of Garden Gate teachers but shifted their focus to the entire Kennedy staff. During Kennedy's implementation year, the Monta Vista cadre doubled, and the first six teachers began peer coaching and demonstrating uses they had developed to other teachers. In the third year, while project staff continued to support Garden Gate and Kennedy faculties, the implementation focus shifted to Monta Vista.

This third school year (1989-90) was also the year in which the conditions of the grant required that statewide dissemination and demonstration of the model to other schools and districts begin.

Research and evaluation activities have tracked the project's implementation since its inception. The research and evaluation team members have participated in and observed dozens of meetings and interviewed teachers, principals, and other staff in participating schools and in district and project offices. We have also observed classes, talked to students, and collected data on needs for, training in, and uses of technology.

This report describes the findings and lessons learned from experience since our first report, "Implementing the Teacher-Centered Model of Technology Use: The First 15 Months." Its main purpose, in keeping with the project's dissemination goal, is to help other schools and districts: (1) determine whether this model or some aspects of it are appropriate for their sites, and (2) develop their own implementation process and know what to expect at various stages. Thus, we first describe progress in each of the three schools. The second section describes the technology acquisition, project staff, and professional development aspects of the grant since the 15-month report. We then turn to how teachers use technology for their own productivity and for instruction and the effects to date on students. Finally, we describe ways in which the project has changed the roles of students, teachers, and administrators and influenced school and district organizational culture.

LEADERSHIP AND GOVERNANCE

CUPERTINO–FREMONT MODEL TECHNOLOGY SCHOOLS PROJECTS

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SUMMARY

The Cupertino Union School District and Fremont Union High School District began implementing their Model Technology Schools (MTS) grant from the state in October 1987. The Teacher-Centered Model used for this demonstration emphasizes:

- Teachers' access to in-class teaching stations, technology labs, and software/materials of their choice.
- Training and individualized assistance for professional development in technology use.
- Peer coaching and team/departmental planning.
- Project staff's and school administrators' support for both professional productivity and classroom instructional uses of technology.

The model presumes that if faculty members are given access to the technologies, knowledge of how to use them, and the power to choose and develop their own tools to meet instructional objectives, the result will be schoolwide integration of technology in the curriculum. This integration, in turn, will enhance students' learning experiences and improve learning outcomes across grades and subjects.

Our 15-month research report documented that when teachers first learn about unfamiliar technology, they are overwhelmed by how much there is to know and how difficult it is to make decisions about hardware and software. Three years in, teachers are no longer fearful of making uninformed decisions. They are now knowledgeable consumers of technology products and sophisticated decision makers about their own professional development. Moreover, they now have an increased appetite for sophisticated equipment.

In 3 years, teachers have learned how to use a variety of hardware and software—for their own productivity and for instructional purposes. Many teachers use technology in the classroom for a variety of purposes, and they cite positive effects on students' motivation, attention, and subject matter learning. Most classroom uses are not yet sufficiently pervasive or different from previous practice for us to see overall effects on students' academic achievement. Teachers are just beginning to focus on uses of technology that promote students' thinking skills.

The ultimate goal of the Cupertino–Fremont MTS project is to integrate technology into instruction in ways that foster development of students' higher-order thinking in various curricular domains. Compared with changes from adoption of new practices under most grant programs, the MTS project is bringing about significantly greater schoolwide changes. Roles of the players—from students to district officials—are changing. School climate and relationships of students, teachers, and administrators are changing. Already much restructuring has occurred as a result of the Cupertino–Fremont

model of integrating technology for student learning. Because enhancing students' higher-order thinking will require further changes in what teachers and students do, we expect additional role changes and organizational restructuring to occur in the next few years. Achieving this next-level goal also requires that teachers go beyond using the new technologies with ease for productivity and instruction. It requires them to teach subject matter differently and to encourage students' learning in new ways. This evolution will require further professional development efforts over the next few years.

I IMPLEMENTATION PROGRESS: THE THIRD YEAR

The Cupertino and Fremont districts are in the heart of Silicon Valley, where parents of many students work in high-tech industrial firms. The three MTS schools are rich in human resources for administration, teaching, and other staff and community roles. The MTS project director has management savvy, technological competence, and a continuing half-time position as director of technology for his home district (Cupertino). The project coordinators—educators who are respected by both elementary and secondary teachers—are skilled trainers of others, well organized, and technologically sophisticated. These advantages of the schools and their human resources mean that flexibility is possible and barriers to implementation are likely to be overcome, so that technology integration is more likely to be achieved in this context than in most school systems.

Each school's grade span (K-6, 7-8, or 9-12) and the characteristics of its faculty and student body influence how the project is implemented and how technology is used. Each school received approximately the same resources for staff development and equipment acquisition in its implementation year, although faculties range from only 17 teachers at Garden Gate to more than 65 at Monta Vista. Monta Vista and Kennedy teachers have preparation periods during the day; Garden Gate's elementary teachers do not. Moreover, because Garden Gate is the only school in which all teachers participated from the beginning of the grant, its implementation was not phased in.

Perhaps the biggest difference in the implementation process has resulted from the nature of each school's administrative leadership and how the roles of the project staff have adapted to each leadership style. The broad goals for teachers at all three schools are the same: to learn how to use new technologies and then employ them for enhancing their curriculum and instruction. All three schools have made a long-term commitment to integrate technology, and they view implementation as a multi-year process. Extensive staff development activities at each school have been the core implementation strategy. But the specifics of how teachers were brought into the project and learned about technology depended on timing of the grant and the principal's strategy for faculty development.

At Monta Vista, the strategy rested on building peer relations among faculty members and on implicit contracts between teachers and site administrators; teachers received equipment in exchange for developing lessons and sharing them with others. At Kennedy, the principal used technology as a vehicle for improving professionalism in each department and uniting the faculty around a common purpose. Garden Gate was faced with the dual challenge of a change in principals and the requirement to implement the MTS project schoolwide from the start, without the luxury of phasing in slowly and learning from the experiences of others. Initially, teachers were oriented to the MTS

project and to instructional television (ITV), computer, and video technologies, persuaded to do personal planning for technology use, and provided with technology stations and software selection assistance. Teachers cooperated in the project as requested and learned how to use a variety of technologies. Over time, they perceived that employing technology was professionally rewarding and rewarded by the principal, district superintendents, and larger community.

In all three schools, site administrators and teachers make decisions about which technologies will be acquired and how they will be used. Faculty members or groups have discretionary software budgets. Each school developed a different mechanism for implementing technology; each in turn has been adopted by the other schools:

- The Personal Learning Plan (PLP), developed at Garden Gate, contained each teacher's individual agenda for learning how to use particular technologies to accomplish his/her professional objective.
- The Departmental Technology Planning (DTP) process at Kennedy engaged departments as groups to decide which equipment and software to acquire for individual and shared use.
- Minigrants were established at Monta Vista for individual teachers or small groups of teachers to use for equipment and materials/software, as well as for time with adjunct duty pay, in return for developing technology-enhanced lessons or other products and then demonstrating their uses to others.

Adoption of technologies and their uses vary by school, as the following updates on implementation progress illustrate.

Garden Gate Elementary School

1989-90 School Facts

Total enrollment: 380 students

Composition: 57.4% White
26.6% Asian
8.4% Hispanic
6.3% Black
1.4% Others

Average class size: 28.5

Per pupil expenditure: $4,086

Number of teachers: 17

Garden Gate was selected by the district to participate in the MTS project for its willing principal and characteristics that included a mix of students more typical of schools across the state than were students at Kennedy and Monta Vista. The 17 faculty members—and a new principal who came in during Year 2 with a background in technology and in special education—work with a variety of categorical programs and special projects. The school receives $44,869 of state economic impact funds and conducts a federal Chapter 1 compensatory education program for approximately 60 children and special day classes for approximately 57 students. In addition, the school houses a State Preschool Program for low-income families, serving approximately 32 children.

When the MTS project began in October 1987, Garden Gate already had 26 computers, some in a lab and some in classrooms. The teachers ranged from those with no interest in technology to those who were experimenting with technology to enhance their instruction. By the second year of the project, after considerable delay, each classroom had a teacher's technology station consisting of an Apple IIGS computer, a large-screen monitor, a VCR, a printer, and a rolling cart. A computer lab had been fully equipped with 17 computers but not yet networked.

Training, demonstration, and staff development based on teachers' Personal Learning Plans were the primary activities during the first 2 years. During the second year, teachers received software budgets as well as continued development and assistance opportunities. Most teachers began using video or computer technology to enhance their own productivity, for instruction, or both. More collegial interaction occurred as teachers increasingly discussed software and equipment purchases and uses for instruction.

Three years into the MTS project, Garden Gate teachers have a much clearer idea of what equipment, software, and training they need to incorporate technology into their classrooms. Teachers can specify to project staff what types of assistance will be most useful to them, and how to select software that will best serve their needs. The project staff's approach to teachers' development continues to evolve to meet their needs. During the third year, Garden Gate teachers preferred to have individual help available, rather than large-group training. A project staff member was on-site twice a week to meet with teachers, and a roving substitute was used to release teachers during classroom time to develop lessons using technologies. Teachers have also been released by grade level to plan and brainstorm ways to incorporate technology into the curriculum.

The third year saw technology know-how and use spread from some to all teachers. During the third year, every teacher has used at least a computer for instruction, and often other types of technology as well. Several teachers have moved to the level of "transparent" use, where technology tools are the automatic choice for lessons in which their use is appropriate. An increasing number of teachers use technology regularly for instruction and informally share their experiences with teachers at their school. A few lead staff development workshops for their colleagues who want to learn about everything from camcorder use to multimedia presentations. Some are using laserdiscs and sharing new software applications that trigger the imagination and problem-solving skills of students.

During the year, all teachers participated in semimonthly dissemination days in which teachers and administrators from other school districts visited the classrooms to see technology lessons in action. Several teachers who have become quite proficient in using technology for particular instructional purposes were also invited to share their expertise at workshops for other districts and at statewide conferences.

Since our 15-month report, several significant events have affected implementation of this project at Garden Gate, including the change in principals, the October 17, 1989, earthquake, and a district-funded renovation to network all computers in the building and renovate the existing Library/Media Center to create a multimedia Guided Learning Center. The renovations disrupted all school operations considerably and resulted in another major delay in use of the Technology Center, now scheduled for completion during the fourth year of the project. (However, see Box 1: Unexpected Benefits of Building Renovation.)

Box 1

UNEXPECTED BENEFITS OF BUILDING RENOVATION

Major building renovations are always difficult, and the one begun during the 1989-90 school year at Garden Gate as part of the district's development of a Guided Learning Center is no exception. In addition to temporary fences, jackhammers pounding during school hours, and teachers having to pack up and relocate temporarily, the computer lab was dismantled. Instead of a room spaciously arranged with 17 computers, teachers were left with a classroom containing 8 networked computers and as much of the library as would fit. The other lab computers were distributed between two classrooms for the duration of the construction project.

One result of this new configuration was that several teachers developed a preference for having a bank of computers in their classroom. The teachers with the computers from the lab found that it was considerably easier to integrate technology into the curriculum with a "mini-lab" right in the classroom.

Similarly, during remodeling, the multipurpose room (part of the Guided Learning Center) was not available for assemblies. Instead, information was sent to the classrooms via the cable network, and students watched "video assemblies" from their desks on the large classroom monitors. This system worked so well that the principal plans to continue using this medium for delivering messages, presenting student awards, and holding "assemblies" throughout the year. Teachers also will be able to transmit video programs between classrooms.

A visit to a Garden Gate faculty meeting indicates the extent to which technology has permeated the school. Topic after topic, although not directly about technology, touches on its use. One teacher suggests using a computer to keep track of the number of laps each student runs in an upcoming P.E. competition lasting several weeks. The principal compliments the staff on the professional look of their individual education programs (IEPs) and letters to parents, now produced with word processing software and printed on a laser printer. When the meeting turns to a discussion of what teachers desire for their classroom work area, they are quick to specify the kind of Macintosh computer they need to do their work, while continuing to use Apple IIGS computers as a teaching station and for student use. Their technological vocabulary is well developed, and all are able to participate in discussions of technology uses that only a few could talk about 2 years ago.

Kennedy Junior High School

1988-89 School Facts

Total enrollment: 693 students

Composition: 70.1% White
26.0% Asian
2.6% Hispanic
1.2% Black
0.1% Others

Average class size: 32.3

Per pupil expenditure: $3,952.24

Number of teachers: 35

Because it articulates with Garden Gate and Monta Vista, Kennedy was selected by the Cupertino district administrators to participate in the MTS project. The students, from relatively affluent families, perform in the 95th percentile on state tests. In 1986-87, when its new principal took on the challenge to reinvigorate the school's mission and morale, Kennedy did not have a technology-using faculty. Only one teacher was experimenting with computer use, and the school's video technologies were outmoded. Using the teacher-centered MTS grant and other school and district assets, Kennedy became a California Distinguished School in 1990.

In the first year of the project, Kennedy's initial cadre of six teachers were involved in technology demonstrations, training sessions, and other staff development activities with the Garden Gate faculty and the initial Monta Vista cadre. The combination of a chance to play a part in the district's goals for technology and the support of a principal who learned along with them and rewarded those who made progress provided the Kennedy faculty with incentives to transform their school practices.

Kennedy was the focus of implementation during the second year of the project and received the bulk of the resources for staff development and equipment acquisition. The principal and faculty began the year with a week-long workshop, in which all learned how to use new technologies and developed products demonstrating these technology applications. They created the Departmental Technology Planning (DTP) process, now used throughout the project, to decide on hardware and software acquisitions for individual and shared access; a significant number of teaching stations and computers were acquired in the spring of the second year. Through varied training, staff and peer support, and release-time activities, all faculty members learned how to use some video and computer technologies; and the initial cadre became teachers of others. Productivity

uses were common, including generating worksheets and tests and using a popular gradebook program. Video (camcorder, VCR, laserdisc) technologies were popular, but faculty in some departments became users of multiple technologies and employed them for classroom instruction.

By the third year, every teacher had access to a computer, and many were using a variety of peripheral technologies. In addition, teachers and students used camcorders and VCRs for a variety of purposes. The project coordinator noticed that "There are more teachers doing multiple things than have latched onto a single thing." Through the principal's efforts and with support from the district and its Apple partnership, a networked Macintosh lab will be ready for use in the second semester of the fourth year (Spring 1991).

Although some departments and some individual teachers lag behind in interest and use, visitors, who came twice a month for MTS dissemination day, saw a wide variety of everyday uses. Teachers are using camcorders and VCRs to give students feedback on their performance in physical education and to demonstrate steps in cooking with teacher-made videos. Teacher-developed HyperCard stacks unfold concepts in science classes, and laserdiscs in art and social studies classes expose students to visual experiences and historical or current events. School secretaries and faculty members are sharing tips on Macintosh programs, and the principal uses an LCD projection pad and a spreadsheet program to develop a budget with department heads. Students are using desktop publishing to produce yearbooks and newspapers, and using camcorders and editing equipment to produce a school-highlights video magazine.

At the end of the third year, the students, faculty, and administration share the belief that they all had a part in making Kennedy a technology-using school. Beginning with the initial cadre, the week-long inservice, and the Departmental Technology Plans, which reflect the state curriculum frameworks emphasis, the MTS implementation process became a vehicle for professional renewal. Principal, faculty, staff, and student interactions on the use of technology increased. This activity in turn contributed to Monta Vista Senior High School spirit. Parents are proud that Kennedy has become a leader in technology. During Parents' Night, they saw a video presentation produced by students and teachers, and the broader community saw Kennedy featured in a *San Francisco Chronicle* article on technology in the schools.

Monta Vista High School

1989-90 School Facts

Total enrollment: 1,493 students

Composition: 65.2% White
27.8% Asian
4.7% Hispanic
0.9% Black
1.4% Others

Average class size: 30.5

Per pupil expenditure: $3,401

Number of teachers: 68

Monta Vista High School administrators, with the endorsement of the Fremont district, participated in the preparation of the original grant proposal in 1987. This ensured that Monta Vista's objectives of enhancing faculty development and peer coaching were incorporated—along with the student learning objectives—as an MTS project goal. Monta Vista is a state distinguished school with a minuscule dropout rate; more than 90% of its graduates go on to 2-year and 4-year colleges. Students from families with one or two computer-using parents are common. Science and business classrooms and some other departments had computers and other appropriate technologies when the project began. However, Monta Vista was not a campus where technology was incorporated across the curriculum into teachers' instructional practices.

In the first year, project coordinators and the school's technology specialist supported the six-teacher cadre's orientation to new technologies or new applications, their hardware/software selections, and their development of instructional units and lessons. With two exceptions, these teachers were already computer users, but they were not making instructional applications. They understood that receipt of additional equipment, software, training, and assistance was contingent not only on their commitment to developing lessons for the classroom but also on their demonstrating technology use to their peers on the faculty. During the inservice education day in the spring of that year, they became the envy of other faculty members; integrating technology into one's repertoire became an aim for other teachers at Monta Vista. By putting new technologies to good use, these teachers and their departmental teammates showed others how to improve mathematics, laboratory science, English composition and speech, accounting, history, and foreign language instruction.

In the second year, school administrators selected the second cadre of six teachers, who also promised to learn, develop, and demonstrate technology uses in return for access to appropriate hardware, software, training, and guidance. Again, new technology uses were developed; used in classrooms for music and art, advanced computer science, mechanical drawing, and industrial design; and also demonstrated to other faculty members, along with those elaborated by the first cadre.

In the third year, Monta Vista was the focus of MTS project implementation. By this time, the principal, vice principal, school technician, and MTS project staff had worked together on technology acquisition and staff development strategies. The school technician and project staff oriented new departmental teams of teachers to technology applications and gave them training and hands-on help. The lesson demonstrations by teachers in the lead cadres, using different technologies for students in different grades and subjects, had motivated more faculty members to try out some technology uses.

Meanwhile, these original faculty teams developed and demonstrated more complex technology-aided instructional methods. Members of the lead cadres were awarded minigrants of paid time and appropriate equipment/software to develop further uses and instructional units, coach their peers in technology use, and—as required for the third-year MTS grant—demonstrate these uses to visitors from other schools and districts. Walking around the high school campus and dropping into various classrooms, visitors could see:

- Several networked computer laboratories where students were being taught business practices and advanced mathematics, or were working on their writing skills.
- Teachers using specialized laserdisc video and microscope-projection equipment in the biology laboratory to explain organs and organisms.
- Students using specialized computer-aided design software in the vocational education classrooms to complete their drafting projects.
- Students working on personal computers available to write their lab reports in physical sciences and teachers working on the computers designing tests, developing handouts, or keeping records.
- Music and art/humanities classes using computer programs and laserdisc programs to involve students more directly in the essence of these subjects.

In the spring of the third year, Monta Vista hosted a big demonstration (165 attendees) of technology uses for superintendents, principals, and teachers from other districts who planned to apply for state technology grants under AB 1470. Project staff and the Monta Vista principals described technology implementation and integration factors, and teachers from Monta Vista, Kennedy, and Garden Gate led a variety of demonstration lessons for various grade levels and curriculum areas for the visitors.

II PROJECT RESOURCES

The MTS funds have supported the acquisition of some equipment in each of the first 3 years, but primarily the project grant has supported the time of project staff and the various professional development activities. In this section, we describe the equipment, how teachers now drive the acquisition process, and how much equipment is funded from sources other than the MTS grant. We also describe the evolution of project staff members' roles, including their major role in the faculties' professional development. Finally, we describe how the project promotes development of teachers' technology uses and what stage it has reached.

Equipment Acquisition and Use

Our earlier report described the time involved in negotiating agreements with vendors and receiving equipment. Initially, major computer acquisitions took almost the entire school year. Now to purchase computers and make them accessible to teachers usually takes only a matter of weeks. The Apple partnership—with the project and the Cupertino Union School District as a whole—plays a part in this, as do purchasing processes expedited by project staff, school principals, and district offices. The Apple partnership, negotiated at the end of the project's first year,* initially represented a trade-off between teacher choice among brands in computer hardware and district needs for school-to-school compatibility and purchasing breaks. Now, the Apple equipment is enthusiastically used and sought after for its capabilities.

Video camcorders and VCRs were the most easily acquired and readily used technology. Many teachers started with these and ITV programming, which was facilitated by aerial and cable installations in Year 2. Software as well as hardware choices are in the hands of the teachers. The ordering, receiving, and installation procedures worked out by project, school, and district administrators now work relatively smoothly, so access to technology is high at each of the three schools.

Table 1 shows that the schools have acquired a considerable amount of equipment. An analysis of what types of equipment they acquired during the 1989-90 school year suggests that the schools are keeping abreast of rapidly changing, increasingly sophisticated technology. For example, equipment purchasing patterns at Monta Vista reveal a movement toward faster, more efficient computers with more memory and greater capabilities, and more sophisticated computer workstations. As teachers continue to learn about hardware, they are not as satisfied with technology that was considered state of the art only a few years ago.

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* At the beginning of the first year, Apple Computer donated $25,000 worth of equipment to each MTS site in California.

Table 1

EQUIPMENT AVAILABLE IN EACH SCHOOL, 1989-90

	Garden Gate	Kennedy	Monta Vista
Apple II computers	47	40+	4
Macintosh computers	8	27	113
ImageWriters	20	19	13
LaserWriters	2	3	8
VCRs	19	25	26
Camcorders	3	9	17
TVs	19	24	26
PC viewers	2	6	37
Video editors	0	2	1
Laserdisc players	1	6	7
Scanners	0	1	2
Slide projectors	4	2	6
Carts/stands	16	24	38
Modems	1	2	4
Tape backups	2	1	1
Overhead projectors	8	21	59
CD ROM players	0	1	1

The More ... the More ...

As teachers see what technology can do to enrich student learning and increase their own productivity, their appetite to have more equipment immediately accessible grows. The costly, fully networked Macintosh labs at the high school look pretty attractive to the junior high teachers. At Garden Gate, teachers who had several computers in their rooms during renovation do not want to give them up. When teachers use computers regularly for their own productivity, they then want the same resource available at home (as some Cupertino district teachers have). Teachers at all three schools have expressed the "need" to have a Macintosh sitting on their desks, both at school and at home.

> "We have created a monster! But, it is a good monster."
> — Site Administrator

Teachers' needs grow as they learn what is available, have opportunities to observe others working with it, and try it out. If state-of-the-art equipment is bought for teachers, it may initially sit idle; but after one teacher successfully uses a new piece of equipment, other teachers soon want it as well, and more are needed. A laserdisc player purchased

for Garden Gate by project staff gathered dust for a year before one teacher found a way to incorporate it into her literature program. After she shared her successful experiences with others, the laserdisc became so popular that teachers now wait in line for a chance to use it. Moreover, the first teacher who experimented with the laserdisc found so many ways to incorporate it into her language arts program, she now wants one permanently installed in her classroom!

As the amount and complexity of technology increase, the amount of time required for setup and maintenance also increases. (See Box 2: Networking an Entire School.)

Leveraging and Pooling Resources

Easy access to technology is prerequisite to its integrated use in schools, but acquiring what is necessary for everyday instruction is expensive. Although project funds provide substantial equipment resources, moving an entire school into technology, especially as technology changes and appetites grow, continues to strain budgets. The project director has sought out and negotiated partnerships whereby project participants receive assistance and training, software, and equipment of various kinds. In exchange, the partners get product testing, instructional information, product demonstrations, and good will in the community. The partnership with Apple, negotiated by the (previous) Cupertino superintendent, leveraged more equipment for project resources. As part of the partnership agreement, Apple provides a staff member as liaison to the district and project staff.

The schools in the MTS project, and their districts, have identified and used many sources of funds other than MTS grant funds to stretch their budgets in purchasing technology and services. The wide variety of uses for technology means that a number of categorical and other targeted funds may be available for technology purchases or training. Garden Gate purchased the MECC Management System, partly with Chapter 1 funds for use with identified youngsters. The lab is managed by a teacher aide, who also assists primary-level Chapter 1 students daily in math and/or reading. The school also received a district grant to improve its P.E. program, which incorporates technology. Kennedy has used school improvement funds and district funds to supplement the MTS grant for equipment purchases. Monta Vista, using a variety of sources, including vocational education and federal Chapter 2 school improvement funds, has more than matched the grant funds. The school has applied $72,000 over 3 years, in addition to the MTS project funding, to acquire hardware and software. The result of this commitment by school and district administrators is more rapid technology acquisition and greater teacher commitment to using technology than could have been expected otherwise.

Box 2

NETWORKING AN ENTIRE SCHOOL

The Vision

At Garden Gate, the vision was to have a computer lab of 17 Apple IIGS systems networked together and a computer in every classroom, all networked to each other, to the lab, and to the office. The network not only links teachers' individual computers to the lab file server to access networked software, it also can enable teachers to read an electronic bulletin board and to send and receive electronic mail, including attendance, grades, and other management information. The principal's office can then exchange information with the district office.

Teachers can choose from a vast array of software what they want to use in their classroom or in the lab by simply accessing the file server. They can model software for students before they accompany them to the lab to do an assignment. Teachers who share the same students for reading or math can access student records from their own classrooms, send messages regarding these students, and make notes in their cumulative files. For students, the benefit is a more coherent, individualized learning program with the opportunity to work in a computer lab, not just on enrichment activities but on assignments that are integrated with the classroom curriculum.

The Reality

Implementing the vision of a networked school has proved to be a most challenging task. During the third year of the project, several primary teachers began using the very limited network in the computer lab and in their classrooms. The file server provided a central location for software and saved teachers' time searching for disks. But even teachers who enjoyed using this network had to disconnect themselves from it when they wanted to use software not on the network. Few teachers found reasons to communicate with others via electronic mail, nor was there any exchange with the principal's office, since this link was not yet functioning.

For instructional purposes, network functioning was not as reliable in the upper-grade wing of the school as elsewhere. Teachers met frustration when they planned a lesson around software on the system, only to discover that it was not accessible that day. Knowing which component of the networked system is malfunctioning is not always easy. One teacher called a network repairman and waited for his arrival, only to be told that the file server, not the network, was malfunctioning, and she would need a different repairman. Upper-grade teachers have found little use for the network because network-appropriate software for upper-grade students has not been available.

With assistance from Apple, the district-funded renovation, and new software licenses, the vision will begin to be realized. However, school administrators would be wise to investigate thoroughly the value of installing a network at their school before committing to it. Networks offer the potential for many wonderful things, but to make it a reality takes not only a desire by teachers to make use of the attractive features, but also a technically reliable system, staff who will administer the network operations, and software that can be put on it.

Roles of Project Staff

The MTS grant supports two project coordinators and half of the project director's and project secretary's time. The director and the coordinators see their role as supporting the school administrators and faculty members in the technology integration process. They also assume the responsibility for liaison with the state and seeing that the grant is properly administered.

As the project has evolved, these staff members have continued to adjust their roles to meet changing needs of the school leaders and teachers. Project staff had combined the state-specified roles of training coordinator and curriculum coordinator—a distinction that did not work out in practice—and both coordinators served in multiple planning and professional development capacities. Coordinators moved their offices to the schools, reflecting a shift from formal workshop and training sessions to teachers' need for on-site assistance. The project director's office remains in the Cupertino district office, but the project staff meet weekly at Monta Vista in the Fremont district. Monthly Site Management Board (principals and project staff) meetings are also held at Monta Vista.

The two project coordinators spend most of their time in the schools providing personal support and assistance to teachers and are therefore key to moving the project forward. As former teachers in the participating districts, the coordinators are insiders who are readily accepted, and their knowledge of instruction and state curriculum frameworks—as well as technology—greatly enhances the ways they can assist teachers.

Responding to teachers' requests, the coordinators provide many types of assistance: helping teachers use new hardware and software, locating sources of materials, teaching classes after school on software applications, and arranging visits to other sites. They have sat with teachers for several 1-hour sessions, providing them the one-on-one support that enables teachers to try new equipment and applications with minimum frustration. As a result, more teachers are trying several types of technology applications in their teaching; more teachers are feeling confident enough to help other teachers, as well as aides and office staff; and more teachers are sharing applications of their new skills at workshops and conferences. Teachers describe the project coordinators in very positive terms: "great," "knowledgeable," "really willing to help," "accessible," "teachers first and then technicians." One principal, asked by a visiting group of administrators what one piece of advice she would give to those beginning a technology project, quickly responded:

> "Don't short the human part of training. If you have a choice between a fancy piece of equipment and a person, choose the person.... Technology can be confusing, and handholding is very important."

By the third year, the value and importance of having the project staff located at the schools were even more evident. An administrator, referring to the continual presence of the project coordinators, commented: "They have brought things along faster."

Providing such assistance proves easier in the junior and senior high schools, where teachers have prep periods. These give teachers the opportunity to work on tasks of their choosing during the normal working day. At the elementary school, the coordinator scheduled one afternoon a week to help teachers in the lab; but when participation lagged, she shifted to making appointments ahead of time with teachers and found herself much more in demand. Recently, the school administration has provided a roving substitute (paid for by the grant) to free teachers from class time to work with project staff. Next year, funds will be used to hire a roving substitute once a month, scheduled in advance, enabling teachers to plan the best ways to take advantage of the project's staff resources.

A project that is educational, technical, and publicly visible asks a lot of the project coordinators. They must play a variety of roles: staff developer, technician, curriculum specialist, public relations spokesperson, tour guide, and on and on. In addition, they help school site administrators in a variety of ways, from planning and arranging inservice activities to writing newsletter articles and contacting repair and resource people. These multiple roles pose time management challenges for the coordinators, who have had to create systems that simplify their work. For example, software review requests and purchase orders used to go through project staff. Now, teachers complete them, with guidelines and a school budget to follow. Also, as teachers become more competent with particular technologies (such as HyperCard), project staff encourage them to teach and help each other rather than turning to project personnel for assistance. This delegation and systematization of their former roles not only leaves more time for the project coordinators to carry out the required state dissemination activities but also helps assure that the project can be sustained without specially funded staff in the future.

As part of the Apple–MTS/Cupertino partnership, an Apple liaison connects project staff, teachers, and principals with the most appropriate person at Apple to handle different purchasing and technical equipment and software operation problems; she has also kept the project participants up-to-date on new developments at Apple.

Professional Development Activities

The bulk of the project coordinators' time is devoted to planning and carrying out professional development activities for teachers. To respond to the changing needs of teachers as they learn about technology, MTS staff development has included an ever-expanding variety of activities from formal training to informal on-the-spot assistance. The process by which teachers move from acquainting themselves with technology and its varied uses to spending time previewing vendors' software and learning to incorporate technology into the curriculum is not linear. That is, a teacher who is an advanced user of

video hardware or software for lesson presentation may be a novice at word processing and need to learn computer skills. Now, typically, for each major kind of hardware or type of application (e.g., word processing, laserdisc, HyperCard), teachers benefit from formal training that introduces the technology and provides time for them to practice. Beyond this training, however, teachers move in and out of various types of professional development experiences, depending on their goals, needs, and what is available. During the third year, teachers were most interested in classroom instructional uses of computer technologies and learning from other teachers through conversation, observation, or videos.

Early in the project, staff development activities focused on creating individual and group (grade-level or departmental) goals for technology use. The act of planning and deciding together proved to be valuable. Creating technology-based lessons or products as a group, with expert help available, has also proved to be a powerful way to learn the tools. In Year 3, professional development activities included small- and large-group training and demonstrations by Apple personnel and other vendors, coordinators, or other teachers; release time for attending classes; district inservice activities; and a drop-in clinic after school in the computer laboratory. The most popular development activity was one-on-one assistance from project coordinators (or other teachers).

Logs of one-on-one assistance reveal that most time was spent teaching word processing programs such as Microsoft Word or Works. Some training was on tool software, such as Excel, PageMaker, and Persuasion. HyperCard was especially popular among Kennedy teachers. Occasionally, teachers were taught "Beginning Mac Skills" or how to use other technology, such as the Apple IIe, the camcorder, or the PC viewer. Although classroom aides, students, and classified personnel were occasionally given this developmental assistance, most one-on-one activities involved teachers.

Staff development in all three schools is now almost totally teacher driven—a major shift from the initial stages of the project implementation. Individuals or groups of teachers define their own training needs, focused on technology projects they choose and design. Now that almost every teacher in elementary and junior high and many in the high school are using technology in some way, the challenge is for teachers to use technology in ways that provide more effective learning experiences for students. The professional development thrust from project staff and school administrators will turn toward higher-order thinking as a student learning outcome.

This next step is a hard one because it goes beyond technology use per se. Teaching in ways that promote problem solving and critical thinking by students is not simply a matter of selecting and using software designed for such purposes. Instructional television, computer software, and video presentations can be effective vehicles for motivating student interest and making concepts clearer, but it is creating and managing students' interactions with the learning environment and the dialogue between teachers and students that lead to the development of higher-order skills.

III USES AND EFFECTS OF TECHNOLOGY

Overview

The findings reported in this section are based on questionnaires administered to teachers at all three schools in February 1990, and amplified by data from observations and interviews. The questionnaire asked how frequently teachers were using technology, the types of equipment they were using, and the objectives underlying this use. Teachers were also asked to describe how technology has affected their teaching, and how it has changed student behavior and attitudes. At both Garden Gate and Kennedy, all teachers completed the questionnaire; at Monta Vista, there was an 85% response rate.

Despite differences among the three schools—implementation timelines, grade levels, and leadership styles—the data show consistent patterns across schools. Teachers' use of technology for both productivity and instructional purposes has increased, as have the different types of technology used. Below we discuss each of these uses, the barriers to more instructional use, and effects on students.

Teachers' Productivity Uses

We define professional productivity to include learning the technology as well as using particular applications, such as for preparing grades and communications to parents; developing worksheets, tests, or curricular units; reviewing software; and setting up the classroom for the use of technology. At all three schools, the amount of time teachers use technology for productivity purposes, in and out of school, increased from an average of 6 hours per week during the 1988-89 school year to 9 hours per week in 1989-90. Only 5% indicated that they still do not use technology for productivity purposes, compared with 19% the previous year. Although the vast majority of teachers use the technology for productivity purposes fewer than 10 hours a week, some report using technology for as many as 30 hours a week.

Teachers at all three schools reported a marked increase in their personal knowledge of technology. For the 1988-89 school year, most teachers rated their knowledge of technology as "low." In comparison, most rated their knowledge as "moderate" (3 or 4 on a scale of 1=low to 5=high) during the 1989-90 school year. For most teachers, increased technology use went hand in hand with increased knowledge. As one teacher stated, "The more you know, the more you use it," although some noted that the more they learned the more they saw there was to learn.

Data also indicate that the nature of technology use changed as well. Some teachers not only have increased the amount of time they spend using technology but also have begun to use a wider variety of technology and materials. Teachers suggested that an increased level of knowledge led to less personal frustration, more efficient use, and, in

some cases, greater motivation to use the technology. Comments such as this were abundant: "Because I could do things of higher quality and more efficiently, I wanted to do more."

Table 2 describes the ways in which teachers are using technology for productivity purposes. As this table indicates, at all three schools a majority of teachers are using technology for preparing instructional materials, worksheets, tests, and homework. Fewer, but almost half, use the technology for lesson planning. Very few use the technology for keeping track of attendance.

Table 2

PERCENTAGE OF TEACHERS USING EQUIPMENT FOR PRODUCTIVITY

	Garden Gate (N = 17)	Kennedy (N = 31)	Monta Vista (N = 57)
Instructional materials	65	74	65
Lesson planning	41	51	39
Preparing worksheets, etc.	59	74	65
Attendance	0	9	5
Grading	35	74	49
Communicating with parents	76	48	18
Other	29	12	14

Despite these similarities, there are some differences across schools in the ways teachers are using the technology. At Garden Gate, for example, the most popular use of technology in the area of productivity is to communicate with parents (76%). In comparison, fewer than half of the teachers at Kennedy and fewer than 20% of the teachers at Monta Vista use the technology for this purpose. These differences are due, no doubt, to the difference in grade levels these schools serve; teachers generally communicate less with parents as students get older. At Kennedy, following schoolwide training on a gradebook program, 75% of the teachers use technology for grading, compared with fewer than half at the other two MTS schools.

By far, the piece of technology most widely used for productivity at all three schools is the computer, with over 90% of the teachers using it for that purpose. The printer and VCR are also popular at all three schools, being used by over 80% of the teachers. The

equipment that is not used widely includes the CD ROM player, the scanner, the video editor, and the laserdisc player. Although a few teachers report using this equipment regularly, most teachers have never used these items.

Teachers cited numerous benefits from using technology to enhance their professional productivity, including the ability to create multiple forms of a test, to make more professional-looking handouts, to give students immediate feedback on their grades or missing assignments, and to update and improve lesson plans, lectures, worksheets, and other assignments quickly. Unfortunately, however, learning to use technology is a time-consuming task that often does not pay off immediately. For teachers who are already pressed for time, such an investment requires a great deal of personal sacrifice and encouragement from peers, trainers, and administrators. However, as the following quotes suggest, for those who do invest the time, efficiency is increased:

> "The time spent [using technology] is about the same, but I accomplish more because I am more fluent with the technology."

> "[Technology] actually creates more work, but the payoff is in the years following."

Teachers' Instructional Uses

Instructional uses include lesson presentation to classroom groups and hands-on experiences by students in the classroom or the laboratory. Teachers at all three schools use technology less for instructional uses than for productivity purposes. As with productivity use, however, more teachers used technology in the classroom for more time during 1989-90 than during the previous year. At all three schools, there has been an increase over the last year from an average of 3.5 hours per week to almost 6 hours. Also during the third year, fewer teachers—all of them at Monta Vista and Kennedy—did not use technology in the classroom.

The VCR, television, and computer are the most popular technological tools for instructional purposes. Over 90% of the teachers who use technology for instruction have used the VCR; approximately 80% have used the computer and instructional television. As with productivity, teachers infrequently use the CD ROM player, the scanner, the video editor, and the laserdisc player for instruction.

There are some interesting differences, however, in the frequency of equipment use across schools. For example, *all* teachers at Garden Gate stated that they use the computer "often" for instruction. In comparison, only 20% to 30% of the teachers at Kennedy and Monta Vista reported using the computer "often." At both Kennedy and Monta Vista, teachers use the VCR and television more often than the computer for instruction.

Although almost all teachers are using technology in their classrooms, some are using it in instructionally more innovative ways than others. (See Box 3: Innovative Uses of Computer Technology to Encourage Active Learning, for three examples.)

Box 3

INNOVATIVE USES OF COMPUTER TECHNOLOGY TO ENCOURAGE ACTIVE LEARNING

- In Sylvia Machamer's primary classroom, a large model layout of a town sprawls over an 8x10 foot expanse of floor. Complete with landmarks, including streets, houses, fire station, library, school, and bus stops, the town represents where the students live down to the details of the house styles, addresses, and pets in the yards. The town has been built by Mrs. Machamer's special education students, and it represents their own homes. Mrs. Machamer quizzed the students on the details of their houses and their neighborhoods. Using Hometown U.S.A. software, she and the students then created the houses and other components on a computer, printed them out, and constructed the town. Helped by repetition, her students sit by their homes and describe them to their classmates, discuss who lives near whom, and who lives near or far from the school. In the process, they learn their addresses and their proximity to other places. She also takes the class on field trips to the local fire station or shopping center as a basis for adding to the town.

- Kennedy biology teacher Chris Heumann has created on his computer an electronic file cabinet that organizes all his presentations, assignments, lab worksheets, and other supporting information that he uses in his classes. Students are free to access the teacher's files on his "Science Mainframe" to complete assignments, review or make up lessons, and do research on report topics. Moreover, Mr. Heumann doesn't have to worry about his papers getting lost or filed in the wrong place. To him, the technology opens the door for students to take responsibility for learning. As he puts it: "The technology gives us a living textbook. Previously, the teacher was the only source of information for students. Now the students can be investigative about learning." Mr. Heumann also uses a camera connected to a TV monitor and hooked up to a microscope for science labs, which he finds "makes the lessons so much more potent.... We are co-investigators, and that is really great."

- Reading an assigned novel and answering questions about it is a traditional English class activity. High school English teacher Dennis Cates uses technology to engage students in thinking about the questions and answers. He places students in groups of two or three and asks them to prepare to lead a discussion of a key concept in *The Great Gatsby* using whatever tools they need—a Macintosh SE, HyperCard, VideoWorks, and an overhead LCD projection panel. Student lessons can take the form of a class discussion, a game, a clever presentation, or a dramatization. Mr. Cates found that "Several projects went well beyond what I expected. A few great projects came out, with some students spending lots more time than was expected." He also finds that he can do a better job of facilitating active discussion with the class by having his analysis points, ideas, and discussion questions in HyperCard and projected on a large screen.

The vast majority of teachers use technology in conjunction with whole-class instruction (see Table 3). Many show videos on the VCR or instructional programs on television. Others use an LCD projection panel to present lectures. This technique has some advantages, such as providing the teacher with the opportunity to modify the information presented, but the approach is not far removed from the use of an overhead projector. Most teachers at Garden Gate (88%) use technology for individual and small-group instruction; fewer than one-third at Kennedy and Monta Vista do so. Consequently, in the secondary classrooms, students have relatively little hands-on experience using technology. In particular courses at the secondary level, students use computers in the technology labs.

Table 3

TECHNOLOGY USE WITH DIFFERENT TYPES OF CLASSROOM INSTRUCTION

(Percent of Teachers)

	Garden Gate	Kennedy	Monta Vista
Individual	88	29	30
Whole class	94	74	60
Small group	88	29	25

For a few individuals at each school, the use of technology has radically altered their approach to instruction. As one teacher commented, "MTS has completely changed the way I teach and the way I think about presenting topics to students and organize my class." Another stated, "I feel I am a better teacher because of the MTS project. I am better organized, [teach] better lessons for my classes, [and] test scores are higher."

Teachers like these have created their own software programs, made videotapes to illustrate particular concepts and procedures, developed student video portfolios, and videotaped student presentations. Others give their students hands-on experience with the technology by having students prepare multimedia presentations, or by giving them assignments in the computer lab. More often than not, these teachers are well versed in the use of a wide variety of technology and spend a great deal of time preparing their lessons. The first teacher quoted above, for example, reportedly spent 30 hours a week learning to use the technologies, organizing equipment, and creating instructional material. This level of use is well above the norm.

A number of teachers this year have gone beyond learning to use one type of technology and have tried using either new technology tools or new applications of what they were already using. In the elementary grades, video presentations have been used successfully to show how one story can be interpreted in a variety of ways, to teach interview skills, and to introduce writing assignments. At Kennedy, the project coordinator noted, "We have more people doing more this year than last year. The level of sophistication is much higher as far as what's going on in the classroom." At Monta Vista, science teachers are regularly using interactive videodiscs and HyperCard to provide multiple ways for students to get access to information.

Some teachers have enjoyed experimenting with multiple technologies for polished products. For example, one English teacher not only published each of his students' poems in a visually pleasing format, but also printed a scanned image of each author next to his or her poem. A preschool teacher used interactive software to have groups of children create picture stories, which they then dictated to the teacher, who entered them for use in class books. She then videotaped students acting out their stories, and they watched the tapes. A sixth-grade teacher had groups of students create illustrated reports using a laserdisc and computer combined.

Barriers to More Instructional Uses

The barriers to more instructional uses most often cited by teachers were time, reliability of equipment, and limited access. Although many voiced enthusiasm about the possibilities of using technology to enhance instruction, even the most motivated and creative complained about the time required, stating that lessons involving the use of technology often took months to prepare. As one teacher noted: "*Teaching* is easier; *preparation* is harder." Some teachers co-develop or share their technology-based lessons with others, but it takes time to develop a repertoire for various subject matters and curricular units. As one principal explained, "Some software is very complex to use, and it affects instructional strategies, which means more change for the teacher. This takes time."

Another common complaint revolved around equipment. In some cases, a relatively small item like a missing power cable or defective floppy disk disrupted an entire day's lesson plan; in other instances, an entire network would fail. Some teachers found that sharing equipment led to problems. When they went to teach a lesson, they often found that even minor changes made by another teacher left them with equipment unusable for their purposes. Typically, these teachers had neither the time nor the knowledge to fix the problem. Teachers who had this type of negative experience were often apprehensive about further attempts to use the technology in the classroom.

As teachers begin to rely on technology, the risk increases that a malfunction is not only a disappointment but a real disruption to the curriculum. It therefore is essential that

equipment can be repaired quickly. A teacher who uses a variety of technologies almost daily exclaimed:

> "When I plug it in, I expect it to work, like my blowdryer or telephone. When I'm planning to use it for a lesson, I expect it to work. If it's unreliable, I'll just stop using it. Paper and pencil can always be counted on."

Even when the equipment was in proper working order, limited accessibility was another common hurdle. Some teachers stated that working out the logistics for their students to go to the computer lab was not worth the "headaches" involved. Others felt intimidated by having to "fight" over popular equipment with other teachers in their department. A few somewhat disgruntled teachers complained that their departments did not receive any "goodies" and decided to become as minimally involved as possible in the project.

In addition to problems with equipment, another common hindrance to the instructional use of technology was a lack of appropriate materials in some curriculum areas. In foreign language, for example, there was no software available with accurate diacritical markings, a feature important to teachers in that department. Mathematics teachers found a similar dearth of adequate software.

In spite of the barriers, 3 years into the project, widespread use of technology is evident in all three schools. Teachers who previously had been frustrated by ignorance of technology are requesting more and more in the way of hardware and software. When teachers first learned about technology, they were apprehensive whether they could master it and were hesitant to try it in front of others. It was difficult to set appropriate goals for personal and departmental use and select hardware and software without having had experience with them. Three years in, teachers are no longer fearful of making uninformed decisions. They have become knowledgeable decision makers and, in fact, now have an increased appetite for sophisticated equipment.

Effects on Students

As teachers began to incorporate technology into instruction, we asked their perceptions of the effects of technology on student behavior, attitudes, and knowledge. The 79 teachers responding to this section of the questionnaire believe that technology has had many positive effects on students, with more teachers at Garden Gate responding positively on every count than at Kennedy and Monta Vista. Only 1 response out of 632 (8 variables for 79 teachers) was at all negative—one teacher felt the technology had a mild, negative effect on student discipline.

The areas in which the largest number of teachers perceived positive effects of technology were their students' knowledge of and interest in the subjects. The following

list ranks the eight variables, in descending order, according to the number of teachers reporting positive effects of technology:

Subject matter knowledge
Interest in subject
Interest in technology
Problem solving
Cooperation
Productivity
Computer skills
Discipline

Teacher interviews and written comments on the questionnaires paint a more vivid description of some of the benefits of using technology in the classroom. (See Box 4: What Teachers Say About Effects of Technology on Students.) Almost without fail, when asked how technology affects students, teachers commented that using technology heightens student interest and motivation. For example, an English teacher at the high school commented:

> "My presentations are more organized, so the kids take better notes.... They *want* to take notes.... Some are going above and beyond what is expected."

Similarly, a business teacher commented that increased attention led to greater understanding on the part of the students:

> "You can tell they're learning. It's overwhelming compared to the chalkboard or the overhead projector. An effective, attractive, well-paced presentation with the LCD panel is great for *maintaining* interest."

English teachers at the high school and junior high levels, as well as elementary teachers using technology for language arts, have commented on the usefulness of the technology in teaching writing. An English teacher said:

> "Even though the kids are working individually, they need and ask for more help than in a regular setting. They are asking *about the writing*, maybe because there is a lot of sharing in the classroom, or maybe because they see how easy it is to edit."

Technology not only has influenced the writing process, it has had an impact on the product as well. Young students who are just learning to write, and special education students who have difficulties with fine motor skills, are especially proud of the stories, poems, and reports they produce on the computer, leading to what the teachers perceive as increased self-esteem.

Box 4

WHAT TEACHERS SAY ABOUT EFFECTS OF TECHNOLOGY ON STUDENTS

About a writing lesson, a first-grade teacher said, "The computer changes a difficult task into a pleasant experience. The children were eager to write to have the opportunity to keyboard.... The printed product is a good motivator. Computer editing is painless compared to a manuscript rewrite."

A kindergarten teacher described her use of the Muppet Word Book software program in teaching reading: "The children felt good about the experience. It wouldn't have been exciting without technology. It is hard to say how much more successful my reading program is because I have technology. I do know that they are reading and they love it!"

A teacher of second- and third-graders used the OMAD Science Database program with teams of students. She said that the students "enjoyed the experience and went far beyond what was expected of them in exploring the software."

An elementary teacher with three computers in the classroom began to see students use the computers as a tool. "Students have been coming up to me and asking to use the computers to complete their reports, rather than asking to play on the computers."

A junior high math teacher used the Macintosh, an LCD viewer, and HyperCard to teach mathematical properties. The teacher commented that the "students learned quickly, passed the test, and use the concepts and vocabulary in class."

A junior high drama teacher described how she used a camcorder to record students' individual presentations: "The student is able to see himself/herself and can be more objective about the performance and understand the teacher's critique. There is no way a student can be objective about his/her own performance unless he/she has immediate video feedback.... At first, the reaction is embarrassment. Later, they are able to look at it critically and improve their performance."

A high school special education teacher had students write business letters on the Macintosh. The teacher stated, "Most students in special education have difficulty with written expression, so they enjoyed seeing their written work put into a nice form.... It was good for their self-esteem. They feel like they accomplished something nice. Students taught one another how to use the Mac."

A high school business teacher used a VCR and a graphing program to teach the concepts of supply and demand. The teacher found that the students "were more attentive. They asked more questions than usual.... They seemed to do better on tests following the lesson."

In discussing a lesson using Vote '88, a videodisc about the presidential election, a high school social studies teacher commented, "The students seemed to have a higher level of retention and comprehension. I was able to introduce important concepts relating to presidential politics easier than before."

Technology also allows teachers to see their students in a different light, as another English teacher explained:

> "I've seen a lot in my kids that I hadn't seen before—creativity and artistic talent.... [Technology] gives an outlet for creativity and critical thinking."

It has taken commitment by people at many levels of the school system to bring about the level of technology access and use and the kind of teaching and learning processes at each school that we now observe. As the next section illustrates, roles played by all parties are changing as administrative leadership, faculty ownership, concerted effort and time by teachers, district staff flexibility, and support from the state and local communities promote systematic restructuring.

IV ROLE AND ORGANIZATIONAL CHANGES

The ultimate goal of the Cupertino–Fremont MTS project is to integrate technology into instruction in ways that foster development of students' higher-order thinking in various curricular domains. Attaining this goal requires that teachers go beyond learning to use new technologies with ease and incorporating them into their ongoing instruction. It requires them to teach differently and to promote students' learning in new ways. This poses a next level of challenge for the faculty's development, the project and school site managers' leadership, and the districts' and community's support.

The focus on changing the teaching–learning process has implications for the roles of everyone involved. Three years into the project, changes in students' and teachers' roles, in each school's climate and culture, and in the nature of district and community support are evident. New roles and organizational relations have emerged in the process of integrating technology into the curriculum.

New Roles for Students

As beneficiaries of effective instructional uses of technology, students become more active learners. Beyond their traditional roles as learners, however, students also take on new roles as experts who serve as resources to faculty and peers, as teachers' assistants, as educational product developers and producers.

Students develop a variety of products, from video magazines of school events to desktop-published newspapers. At Kennedy, for example, the monthly video magazine is broadcast to every classroom through the school's cable network. This project involves students working on story lines and reporting in the journalism class; they also spend a great deal of their own time after school developing ideas for succinct presentations and producing taped sequences. Students who edit videotapes for others not only produce in a new medium, but find that they can provide expert assistance to teachers or others in using this medium.

The students directly involved in such productions are very proud of their work. For some, it is the first time they have been recognized and acknowledged by their peers as having some valuable knowledge. Being involved in other uses of technology, including desktop publishing the school newspaper and yearbook and regular use of a camcorder to film in-class presentations for peer review, critique, and discussion, has also taught students about production values, rhetoric and argument, and dramatization.

Teachers at each school have found a few able students who have provided needed support services and are now recognized as important resources in technology use. Students process classroom management information for teachers; for example, one high

school student created stylized seating charts and is now working on a plot diagram in SuperPaint for a demonstration to the class.

New Roles for Teachers

When teachers reach out to help other teachers, they involve themselves in an activity that is not traditionally a part of their job. Whether teachers have formal time or monetary reimbursement or are informally assisting their colleagues, they are involved in peer coaching and staff development roles. As teachers gain confidence using technologies and are encouraged to share their ideas and methods at school inservice days and local workshops, they become recognized in this new role. Professionalism and collegiality are enhanced in the process, and what was once thought of as a "project" becomes a school reform process. The teacher-centered project has encouraged teachers to redesign their jobs. Administrators share authority and ask teachers to assume responsibility for improving the school's educational program.

Teachers have new decision-making roles as consumers of hardware and software, with more discretionary budget authority. Having control over their own software budget means that teachers spend time deciding how to present and develop the curriculum for their students.

Changes over the 3-year period in the roles of project coordinators have fostered teachers' role changes. Coordinators have gone from teaching others to use technology and ordering materials to assisting teachers in developing their own uses and encouraging teachers to share their knowledge and assist their colleagues. They also have established systems for software purchasing and ordering and for signing up and getting credit for outside coursework.

Teachers also have the opportunity to see themselves in the role of "expert" when visitors enter their classrooms and learn from them how they have used technology. The third year has brought a substantial increase in dissemination activities. The project hosted 466 teachers and administrators from districts around the state during the year, and teachers demonstrated their new methods. These activities included semimonthly visitation days at each school for visitors from around the state and a day of presentations directed at AB 1470 applicants. Several teachers have begun giving workshops to teachers in other districts and at statewide conferences. Districtwide institutes for teachers and CUE presentations by teachers, coordinators, and principals, along with the production of catalogues and newsletters describing the project, also constitute dissemination activities.

The large number of visitors brought both benefits and costs to the project. (See Box 5: The Costs and Benefits of Dissemination.) Visitors were extremely complimentary and reported that the visits were valuable. Staff and students were

Box 5

THE COSTS AND BENEFITS OF DISSEMINATION

The demands of the state grant for dissemination activities and products and the large number of visitors to the three school sites have added demonstration and training to the schools' and teachers' roles. This has benefits in terms of esteem, but there are also costs.

As showplaces for visitors from districts around the state, the districts and school sites share a sense of pride. In addition, the dissemination activities boost the self-esteem of students, administrators, staff, and especially teachers. At first, teachers are eager to have visitors; in fact, there were complaints from some teachers who were not visited—even at Monta Vista, where the high school faculty do not favor interruptions for extra preparation and presentations in their loaded schedules.

Teachers excited about using technology generally want to show their capability during special demonstration events (e.g., workshops for other teachers from the district, AB 1470 grantees). Sharing new techniques with teachers from one's own school is satisfying, but being called on (and compensated) to demonstrate expertise in other schools and districts is even more rewarding. Having an audience has motivated some teachers to try new and exciting ways to use technology and to package their uses into presentations for other professionals. Several have become "stars" among professional peers and envisioned new and different career paths for themselves.

However, preparing and doing presentations can take attention and time away from teaching one's own students in the classroom. Especially when project leaders reward teachers for these dissemination activities, the teachers are more inclined to adapt, rehearse, and re-present finished lessons than to develop curriculum units that would serve their students best. For example, one teacher spent 8 hours indexing scenes and creating directions in a laserdisc story to tailor a successful classroom unit to workshop participants. Teachers are pleased to be asked to run workshops outside their district, but this exacts a toll when they are away from their own classes. In addition, the token compensation often does not cover the amount of preparation time for the workshop or the cost for a substitute teacher.

Visitors also take up time of the principals, MTS project staff, and students who otherwise would be focusing on curriculum and learning. We have seen that when schools focus on integrating technology to improve teaching and learning, roles shift and the organization restructures to foster those purposes. Demonstration and training roles may detract from improved teaching and learning.

pleased with the compliments and attention, and were inspired to devote considerable energy to preparing and presenting projects for visitors. But the time that teachers, principals, and project staff put into hosting visitors was usually time away from concentration on their usual instructional engagements and the progress of their students' learning. The next year will show the degree to which an appropriate balance can be maintained so that technology continues to be appropriately integrated to enhance student learning while implementation processes and results are shared with local and statewide audiences.

School Change

The schoolwide nature of the project, its focus on teacher involvement in planning and decision making about technology, and the transition from use of technology by a few users to its use by most have brought about palpable changes in each school. Students, teachers, and administrators are visible users of technology, and its centrality to the main education mission in each school is evident. The fact that everyone is involved—students, teachers, administrators, support staff, and parents—and that schoolwide implementation of technology results in new roles and relationships actually changes the culture of the school. Departmental and schoolwide decisions create new bonds and a sense of community. Teachers helping other teachers, school secretaries and students helping teachers and each other—these are new relationships in school organizations.

The changing role of the principal has been the key to change in the school. Principals and teachers shared schoolwide planning for technology and decision making about staff development activities. Faculty members made decisions about professional productivity and teaching objectives, and principals held them accountable for using technology to these ends. Principals have inspired teachers with a vision of where technology can take them and encouraged them individually and collectively in the struggle to acquire and use hardware and software appropriate to their own objectives. In some cases, they have been role models by using computers in their daily work and producing memos or newsletters that are more effective because they catch the eye. Occasionally, a principal has taken the time to learn to use new software or equipment in order to provide hands-on assistance to teachers.

District Support

The kinds of changes occurring in the MTS schools could not happen and certainly would not persist without the support of each district for the changing needs of its schools and without the trustful working relationship between the two districts. Although the Cupertino Union School district is the administrative/fiscal agency for the project, both Cupertino and Fremont Union districts incorporated the MTS project in their own districtwide plans and goals, beginning with the original grant proposal. As technology integration progresses, they continue to back the schools by adjusting district procedures and providing appropriate resources as the schools' needs change. They also require much of these schools and expect them to be demonstrators of technology integration to other schools in the districts.

Cupertino Union School District

Cupertino had technology integration as one of its district goals a year or more before applying for the MTS grant, has an Apple Classroom of Tomorrow site at the Stevens Creek Elementary School, and now has an above-average ratio of computers to students

in each of its 22 elementary and junior high schools. Thus, to the Board of Education and district officials, the MTS project is not a separate add-on to the main mission of the district but an integral part of its educational objectives. The state grant is viewed as fostering the district's objectives. The project staff is expected to meet state requirements of the grant as a matter of course.

The role the district plays shifts with the stages of the project. When the MTS grant was awarded, the Cupertino district assumed responsibility for housing project staff, setting up the budget accounts, and coordinating with the Fremont Union High School District. The idea of starting the project not only at the elementary level but also in the secondary schools was a way that both districts could share the grant resources before the third year, when high school implementation was scheduled. This resulted in initial cadres of six teachers at the secondary levels and three implementation cohorts at Monta Vista.

The Cupertino district superintendent played a major role in an early technology acquisition phase by negotiating a partnership deal with Apple Computer, Inc., for the entire district and Monta Vista High School (as a participant in the MTS project). The quid pro quo for Apple was the research and evaluation findings and the demonstration of its products. Because the Cupertino–Apple agreement required exclusive use of Apple equipment, the top-level decision making had to be reconciled with decision making and hardware–software choices at the school, department, and individual teacher levels. But project administrators and teachers have adjusted to limitations in choice of hardware and see benefits from economies of scale in this purchase decision. The long-run benefits of the partnership for the project teachers and others in Cupertino district schools are now evident; Apple has donated additional computers, making more equipment available and accessible.

Teachers at Garden Gate and Kennedy schools are benefiting from the district's investments—in take-home computers for teachers' learning and productivity use, free tuition at the Institute for Computer Technology, arrangements for professional education credits for participating in MTS inservice staff development activities, and the like. Teachers also contribute to Cupertino district needs, for example, by providing inservice workshops or demonstrations for teachers from other schools at the request of district officials.

This year, renovations of six schools to accommodate technology have figured heavily in district–school relationships. As a model technology school, Garden Gate will benefit from the renovations in which the district has been investing since November 1989. However, still under pressure to meet goals of the MTS project, including disseminating information on technology use to visitors, everyone connected with this elementary school and MTS has been inconvenienced by the nonaccessibility of classrooms, offices, and playgrounds, not to mention technology labs and networks.

Fremont Union High School District

The Fremont district is very supportive of Monta Vista High School as a star among its high schools. With district support, Monta Vista administrators and teachers participated in the MTS grant application process with staff from the Cupertino district office. They ensured that the project featured Fremont's and Monta Vista's major staff development goals, including instructional improvement and peer coaching. The principal of Monta Vista keeps district office and board officials apprised of MTS progress; and Monta Vista site administrators carry out the project in accordance with their school's goals, keep up their obligations to the state grant, and represent the interests of the school and district with MTS project and Cupertino staff.

The Fremont district schools are used to articulating with the Cupertino district schools, and there is considerable respect and trust between the districts' administrators. The Fremont district is less invested in technology goals per se, and the board and district officials have had no conflicts with Cupertino over the MTS project.

The technology acquisition process provides an example of the easy working relationships between the districts. Fremont and Cupertino adjusted their ordering and purchasing processes so that Monta Vista obtains hardware and software with no barriers and little paperwork. Such cooperation in ordering of teachers' materials, making adjunct duty payments to teachers, acquiring capital equipment, and the like, is very important in a technology implementation project. Some technology purchases are processed through the Cupertino district, purchased with funds from the state MTS grant. Some are purchased directly through the Fremont district from Monta Vista or Fremont grants, such as the federal Chapter 2 program for improving school effectiveness. When Monta Vista administrators determined that minigrants would motivate teachers to develop and demonstrate instructional technology products, the district approved them for reimbursing teacher time.

Two of the MTS staff development coordinators have been from the Fremont district teaching force, including a mathematics teacher, the only coordinator who has been on the staff of the MTS project since the beginning of the grant. Their understanding of the district's policies, union agreements, and curricular objectives has made Fremont teachers' participation go much more smoothly than it would have with an outsider.

The final 2 years of the project are likely to bring further role and organizational changes in the participating schools and districts. The research and evaluation staff will continue to document such restructuring due to the technology integration process, and assess the evolving effects of technology use on teaching and learning.